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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Materiel Command

SUPPLEMENTARY SPIN TESTS OF A 1/20-SCALE MODEL OF THE BELL XP-39E AIRPLANE

By A. I. NEIHOUSE

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

August 31, 1942

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INTRODUCTION

As a result of the loss of the first XP-39E airplane due to an uncontrolled spin, and at the request of the War Department received in their letter to the NACA, March 31, 1942, additional tests have been made of the corresponding 1/20-scale spin-tunnel model. Tests were made for the normal full load condition and also for the loading condition corresponding to that of the airplane at the time of the crash, that is, with guns, ammunition, and half of the fuel removed from the wings. The model tests were made with the tail arrangement corresponding to that of the airplane at the time of the crash, as well as with numerous modified tail and contour arrangements in an attempt to evolve satisfactory recovery characteristics.

The tests were started on April 2, 1942, and completed in approximately two weeks, with the development of several alternate tail arrangements giving reasonably satisfactory recoveries for normal spinning control configuration. The tests were witnessed by Mr. Melvin Shorr, of the Materiel Center at Wright Field, and Mr. Paul C. Emmons, of the

Bell Aircraft Corporation, to whom records of the test data were furnished. Colonel R. P. Swofford, of the Materiel Center, Wright Field, also witnessed part of the tests.

A preliminary report of the results of the tests has been forwarded to the Materiel Command at Wright Field.

A brief check of a tail parachute installation for the airplane was also made.

APPARATUS AND MODEL

The tests were performed in the NACA new 20-foot free-spinning wind tunnel, the operation of which is, in general, similar to that of the old 15-foot tunnel as described in reference 1.

A description of the model is given in reference 2 covering the original tests of the model. For the current tests, however, the basic vertical tail arrangement tested was that shown in figure 1 (taken from drawing 23-943-036 of the Bell Aircraft Corporation), corresponding to the arrangement on the airplane at the time of the crash.

As previously mentioned, in addition to tests for the normal full load, described in reference 2, tests were made at a loading simulating that with the guns, ammunition, and half of the fuel removed from the wings. Mass information for the latter loading was furnished by Mr. Emmons of the Bell Company. This latter loading is referred to as the "flight loading."

Modifications tested on the model are shown in figures 2 to 16.

TEST CONDITIONS

The loading conditions of the model for the current tests corresponded to the following mass distribution of the airplane with landing gear retracted:

	Normal full loading	Flight loading (guns, ammunition, and 50 percent of fuel removed from wings)
Weight, pounds	8984	8053
x/c	0.254	0.248
z/c	0.138	0.138
I_X, slug-feet^2	6361	4289
I_Y, slug-feet^2	7357	7446
I_Z, slug-feet^2	12901	10534
$\dfrac{k_X{}^2-k_Y{}^2}{b^2}$	-28×10^{-4}	-98×10^{-4}
$\dfrac{k_Y{}^2-k_Z{}^2}{b^2}$	-155×10^{-4}	-96×10^{-4}
$\dfrac{k_Z{}^2-k_X{}^2}{b^2}$	183×10^{-4}	194×10^{-4}

where

x/c is the ratio of the distance of the center of gravity aft of the leading edge of the mean aerodynamic chord to the mean aerodynamic chord.

z/c is the ratio of the distance from the center of gravity to the thrust line to the mean aerodynamic chord, positive when the center of gravity is below the thrust line.

I_X, I_Y, and I_Z are the moments of inertia, and k_X, k_Y, and k_Z are the radii of gyration about the body axes X, Y, and Z, respectively.

b is the span of the airplane.

$\frac{k_X{}^2-k_Y{}^2}{b^2}$, $\frac{k_Y{}^2-k_Z{}^2}{b^2}$, and $\frac{k_Z{}^2-k_X{}^2}{b^2}$ are nondimensional mass-distribution parameters which, for a given attitude and rate of rotation, determine the inertia yawing-, rolling-, and pitching-moment coefficients, respectively.

The model tests were at an equivalent spin altitude of 6000 feet (ρ = 0.001988 slug per cubic foot).

The limits of accuracy of the weight and mass distribution of the model for the current tests are estimated to be:

Weight		±2 percent
Center-of-gravity location		±2 percent M.A.C.
Moments of Inertia	I_X	5 percent low to 10 percent high
	I_Y	5 percent low to 10 percent high
	I_Z	5 percent low to 10 percent high

The normal control displacements used for the current tests (given on Bell drawing 23-976-001) were:

Rudder	±25°
Elevator	25° up, 15° down
Ailerons	25° up, 10° down
Flaps	45° down

For the current program, tests were also made with a rudder setting of ±30°, and with elevator settings of 30°

and 35° up. Brief tests were also made with varied aileron settings.

RESULTS

A complete summary of the results of the investigation is presented in table 1. The results for the more satisfactory tail arrangements are given in charts 1 to 5.

Tests were generally made for both right and left spins, the data presented usually being for the spin direction giving conservative results (flatter spins).

Recovery turns were taken as the number of turns the spinning model made from the time the controls were moved until the spin rotation ceased.

PRECISION

Spin-tunnel results are believed to be the true values given by the model within the following limits:

V . . . . ±2 percent
Turns for recovery . . . . ±1/2 turn

The preceding limits may be exceeded for certain cases where it is difficult to handle the spin in the tunnel due to the wandering or oscillatory nature of the spin, or to a very high rate of descent.

Comparison between model and airplane results (references 1 and 3) indicates that because of scale and tunnel effects, lack of detail in the model, and differences in operators' technique, the spin-tunnel results are not always in complete

agreement with full-scale spinning data. In general, for a given loading condition and control setting, the model steady-spin results have shown a somewhat smaller angle of attack, a somewhat higher rate of descent, and from 5° to 10° more outward sideslip at a given angle of attack. The comparison made in reference 2 showed that 80 percent of the model recoveries predicted satisfactorily the corresponding full-scale recoveries, and that 10 percent underestimated and 10 percent overestimated the full-scale recoveries.

DISCUSSION

Two conditions of spinning equilibrium were usually possible for the model for the current tests, one at a low angle of attack from which recovery was satisfactory, and the other at a moderately high angle of attack from which recovery was unsatisfactory. This was consistent with the results previously obtained for the XP-39E model, as reported in reference 2. The current program was concerned entirely with the improvement of recoveries from the flatter spin. For each configuration tested, the model was launched flat, with rapid rotation in the direction which tended to give the flatter spins.

It must be appreciated that because the model had previously been tested and had suffered a certain amount of damage, it was rather difficult to secure accurate quantitative data for the current tests which would agree

closely with results previously obtained. This accounts for inconsistency in a few instances between current results and comparable previous data reported in reference 2. Also, because of the apparent sensitivity of the model to small inadvertent dimensional modifications, due to damage during testing, corresponding control configuration gave varied quantitative results in a few instances for the current tests.

PRELIMINARY TESTS

Preliminary results indicated that the basic tail arrangement for the current tests (similar to that on the airplane at the time of the crash) was slightly inferior as regards recovery characteristics to that originally tested on the model and reported on in reference 2. Brief tests made with the loading simulating guns, ammunition, and half of the fuel removed from the wings (flight loading) demonstrated that whereas for the model with normal full load, ailerons when set against the spin (left aileron up and right aileron down in a right spin) expedited recovery, for the flight loading, ailerons when set against the spin had an adverse effect, and when set with the spin hastened recovery.

The preliminary tests indicated that tunnel and flight results were in fair agreement, the difference between

results shown in reference 2 and those obtained by the test pilot being apparently due to tail and loading changes.

TESTS WITNESSED BY MATERIEL CENTER AND BELL AIRCRAFT CORPORATION REPRESENTATIVES

The results indicated that a major change in the airplane design would be necessary to insure satisfactory recoveries from spins for normal control configuration. It was agreed that a satisfactory solution would be considered one which would give a two-turn recovery by rudder reversal from full with to full against the spin when the ailerons were neutral and elevator up 35° (normal spinning control configuration) for the clean condition (flaps neutral and landing gear retracted), and for which recovery would not be critically affected by small variations in the aileron or elevator-up settings. Since lowering the elevator from the 35°-up setting tended to slow recovery, most tests were made with smaller elevator-up settings so as to obtain conservative results.

Numerous dimensional modifications were tried in an attempt to improve the recovery characteristics of the model and the results are presented in table 1, in the order in which they were obtained. The results for the arrangements which were most effective are presented again in charts 1 to 5.

The tail modifications which afforded the most satisfactory results, based on the criterion previously mentioned, were as follows:

(1) Additional fin and rudder area below rear portion of fuselage and lower portion of rudder (modification 2)

(2) Lengthened tail (modification 15)

(3) Vertical surfaces moved aft (modification 22)

(4) Antispin fillets (modification 27)

(5) Additional vertical fin area below fuselage (modification 28)

In general, results obtained from spins for the landing condition (flaps down 45°, landing gear extended) indicated slower recoveries than from corresponding spins in the flying condition.

MODEL TAIL-PARACHUTE TESTS

Brief model tests were made with tail parachutes corresponding to diameters of 3.5, 5, and 6.5 feet with bridle line approximately 22 feet long. The results of the model tests indicated that a chute of 5 feet in diameter should be effective as an antispin device for the XP-39E airplane, if a bridle line approximately 22 feet in length is used. Current tail-parachute tests in the spin tunnel indicate, however, that a tail chute

8 feet in diameter, with a bridle line of at least 30 feet, is generally desirable.

CONCLUDING REMARKS

Results of the current spin-tunnel tests of the Bell XP-39E model with tail modifications indicated that, as previously demonstrated by the original tests, two types of spins were possible and that although recovery characteristics for the steeper spin were satisfactory, improvement in recovery from the flatter spin was desirable. Also, as previously reported, ailerons set against the spin were favorable for the normal loading and ailerons with the spin, adverse.

The current tests indicated that:

1. Removal of guns, ammunition, and fuel from the wings, or using up of the ammunition and fuel therefrom, tended to reverse the aileron effect.

2. The tail actually installed on the airplane was somewhat inferior as regards spinning to the tail arrangement originally planned for the airplane.

3. Recoveries from the normal landing condition were slower than those from the normal flying condition.

4. Addition of fin area below the fuselage in the vicinity of the tail plane, addition of rudder area to the bottom of the rudder, installation of antispin fillets forward of the horizontal surfaces, lengthening the tail,

moving the vertical surfaces aft, and increasing the maximum elevator-up setting were all quite effective in improving the recovery characteristics of the airplane for the normal spinning control configuration.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 31, 1942.

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REFERENCES

1. Zimmerman, C. H.: Preliminary Tests in the N.A.C.A. Free-Spinning Wind Tunnel. Rep. No. 557, NACA, 1936.

2. Neihouse, A. I., and Klinar, J. W.: Spin Tests of a 1/20-Scale Model of the Bell XP-39E Airplane. Memo. rep., Air Corps, NACA, Feb. 1942.

3. Seidman, Oscar, and Neihouse, A. I.: Comparison of Free-Spinning Wind-Tunnel Results with Corresponding Full-Scale Spin Results. Memo. Rep., NACA, Dec. 1938.

TABLE 1

SUMMARY OF XP-39E

SPIN-TUNNEL RESULTS

DIMENSIONAL MODIFICATION	DESCRIPTION OF MODIFICATION	SPIN DIRECTION	LOADING	CONTROL SETTINGS RUDDER INIT.	CONTROL SETTINGS RUDDER FINAL	ELEV.	AILERONS	VELOCITY FT/SEC, FULL-SCALE (INIT. RUDDER SETTING)	RECOVERY TURNS	REMARKS
None	Tail on airplane at time of crash (Fig. 1)	R	Normal	25W	25A	25U	Neutral	176	$3\frac{3}{4}$,	
None		R	Normal	25W	25A	15D	Full W	176	8, 13	
1	Vertical area added below fuselage and rudder (Fig. 2)	R	Normal	30W	30A	15D	Full W	188	4, $5\frac{1}{2}$	
1		R	Normal	30W	30A	30U	Neutral	188	$2\frac{3}{4}$, $2\frac{1}{2}$	
2		R	Normal	30W	30A	30U	Neutral	207	$\frac{3}{4}$, 1	
2		R	Normal	30W	30A	15D	Full W	188	$2\frac{3}{4}$, $2\frac{3}{4}$	
3		R	Normal	30W	30A	15D	Full W	182	$3\frac{3}{4}$, $3\frac{1}{2}$	
3		R	Normal	30W	30A	30U	Neutral	194	$2\frac{1}{2}$	
3		R	Normal	25W	25A	25U	Neutral	176	$3\frac{1}{4}$, $3\frac{1}{2}$	
2		R	Normal	25W	25A	25U	Neutral	191	2	
2		R	Normal	25W	25A	30U	Neutral	191	$1\frac{1}{2}$	

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TABLE 1 (continued) 2

4	Dorsal fin (Fig. 3)	R	Normal	25W	25A	30U	Neutral	182	5	
4		R	Normal	25W	25A	25U	Neutral	182	5	
5	Large dorsal fin (Fig. 3)	R	Normal	25W	25A	25U	Neutral	176	$7\frac{1}{2}$	
6	Increased fin area (Fig. 3)	R	Normal	25W	25A	25U	Neutral	176	10	
7	Increased rudder area (Fig. 3)	R	Normal	25W	25A	25U	Neutral	197	3, $4\frac{1}{4}$	
8	Circular end plates (Fig. 4)	R	Normal	25W	25A	25U	Neutral	182	6	
9	Rounded tips (Fig. 4)	R	Normal	25W	25A	25U	Neutral	170	$6\frac{1}{2}$	
9		R	Normal	25W	25A	15D	Full W	166	∞	
10 + 9	Added fuselage area (Fig. 5)	R	Normal	25W	25A	15D	Full W	166	∞	
11 + 9		R	Normal	25W	—	15D	Full W	304	------------	Very steep
12 + 9		R	Normal	25W	25A	15D	Full W	194	11, ∞	
12 + 9		R	Normal	25W	25A	25U	Neutral	179	∞	
13 + 9		R	Normal	25W	25A	25U	Neutral	197	$4\frac{1}{4}$	Two types of spin possible.
13 + 9		R	Normal	25W	25A	25U	Neutral	304	1	
14 + 9	Raised stabilizer (Fig. 6)	R	Normal	25W	25A	25U	Neutral	176	4, 5	
14 + 9		R	Normal	30W	30A	30U	Neutral	176	More than 3	
14 + 9		L	Normal	30W	—	30U	Neutral	304	------------	Very steep
14 + 9		R	Normal	30W	30A	15D	Full W	176	7	

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TABLE 1 (continued)

14 + 9		R	Normal	30W	—	30U	Full A	374		Very steep and wandering
14 + 9		R	Normal	30W	30A	30U	Both 10°D	176	$5\frac{1}{2}$	
14 + 9		R	Flight	30W	30A	30U	Full A	176	$2\frac{1}{2}$	
15 + 9	Tail lengthened (Fig. 7)	R	Normal	25W	25A	25U	Neutral	304	$\frac{3}{4}$, $\frac{3}{4}$	
15 + 9		R	Normal	25W	25A	15D	Full W	188	$5\frac{1}{2}$, 7	
15 + 9		R	Normal	25W	25A	15D	Neutral	182	8	
16 + 9 + 15	Vertical tail height increased (Fig. 7)	R	Normal	25W	25A	15D	Neutral	170	$6\frac{1}{2}$, 6	
17 + 9 + 15	Vertical tail height decreased (Fig. 7)	R	Normal	25W	25A	25U	Neutral	304	$\frac{3}{4}$,	
17 + 9 + 15		R	Normal	25W	25A	15D	Neutral	191	$5\frac{1}{4}$, $5\frac{1}{4}$	
17+3+9+15		R	Normal	25W	25A	15D	Neutral	194	$2\frac{1}{4}$	
17+3+9+15		R	Normal	25W	25A	15D	Full W	232	$1\frac{1}{4}$, $1\frac{1}{4}$	Steep spin
17+1+9+15		R	Normal	25W	25A	15D	Full W	239	$1\frac{1}{2}$	
17+9+15		R	Normal	25W	—	15D	Full W	239		Steep spin
17 + 9		R	Normal	25W	25A	15D	Neutral	170	∞	
17 + 9		R	Normal	25W	25A	15D	Full W	176	∞	
18	Anti-spin fillets (Fig. 8)	R	Normal	25W	25A	15D	Full W	194	$3\frac{3}{4}$	
18		R	Normal	25W	25A	25U	Neutral	210	2, 3	
19		R	Normal	25W	25A	25U	Neutral	194	More than 4	

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TABLE 1 (continued) 4

20	Fin area added (Fig. 9)	R	Normal	25W	25A	25U	Neutral	210	$2\frac{1}{2}$, $2\frac{3}{4}$	
21 + 20		R	Normal	25W	25A	25U	Neutral	223	2, $1\frac{1}{2}$	
22 + 9	Vertical tail surfaces shifted aft. (Fig. 10)	R	Normal	25W	25A	25U	Neutral	220	2, 2	
22 + 9		R	Normal	25W	25A	15D	Neutral	176	$3\frac{1}{4}$, $4\frac{1}{2}$, $5\frac{1}{2}$	
22 + 9		R	Normal	25W	25A	15D	Full W	220	4, $3\frac{1}{2}$	
22 + 9		R	Normal	30W	30A	15D	Neutral	182	4	
22 + 9		R	Normal	25W	25A	15D	Full A	185	$3\frac{1}{2}$	
22 + 9		R	Normal	25W	25A	30U	Neutral	207	$1\frac{1}{4}$	
22 + 9		R	Normal	30W	30A	30U	Neutral	207	$1\frac{1}{4}$	
22 + 9		R	Normal	30W	30A	30U	Full W	185	$2\frac{1}{4}$	Wandering and oscillatory.
22 + 9		R	Normal	30W	—	30U	Full A			Steep spin
22 + 9		R	*Normal	25W	25A	25U	Neutral	194	$2\frac{1}{2}$, $1\frac{3}{4}$	
22 + 9		R	*Normal	25W	25A	15D	Full W	188	4, 5	
22 + 9		R	*Normal	25W	25A	15D	Full A	182	$4\frac{1}{4}$, $4\frac{1}{4}$	
22 + 9		R	*Normal	25W	25A	30U	Neutral	191	2, $2\frac{1}{4}$	
22 + 9		R	*Normal	25W	25A	0	Neutral	185	$3\frac{1}{2}$, $3\frac{1}{2}$	
20 + 1 + 9		R	*Normal	25W	25A	25U	Full W	194	$3\frac{1}{2}$, $3\frac{1}{4}$	
20 + 1 + 9		R	*Normal	25W	25A	25U	Neutral	194	$1\frac{3}{4}$, $1\frac{3}{4}$	
20 + 1 + 9		L	*Normal	25W	25A	25U	Neutral	194	$1\frac{3}{4}$	
20 + 1 + 9		R	*Normal	25W	25A	15D	Full W	182	$4\frac{1}{2}$, $4\frac{1}{2}$	

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TABLE 1 (continued) 5

21+20+9		L	*Normal	25W	—	25U	Neutral	-------------------		Steep spin
21+20+9		L	*Normal	25W	25A	15D	Full A	194	$1\frac{1}{2}$, 2	
21+20+9		R	*Normal	25W	25A	15D	Full W	191	$3\frac{3}{4}$, $3\frac{3}{4}$	
21+20+9		L	*Flight	25W	25A	15D	Full A	182	5, 3, 4	
21+20+9		L	*Flight	25W	25A	25U	Full A		$\frac{3}{4}$ ---------	Very steep spin
9		L	*Flight	25W	25A	25U	Full A	188	4	
20+1+9		R	Normal	25W	25A	25U	Neutral	220	$1\frac{3}{4}$	
20+1+9		L	Normal	25W	25A	30U	Neutral	210	$1\frac{3}{4}$	
20+1+9		L	Normal	25W	25A	15D	Full W	194	4, $4\frac{1}{2}$	
20+1+9		L	Normal	25W	25A	30U	Full W	194	3 to $3\frac{1}{2}$	
20+1+9		L	Normal	25W	25A	30U	Full A		$\frac{1}{2}$ ---------	Steep spin
20+1+9		L	Normal	25W	—	15D	Full A	-------------------		No spin
20+1+9		L	Flight	25W	25A	15D	Full A	188	$2\frac{1}{2}$, $2\frac{3}{4}$	
20+1+9		L	Flight	25W	—	30U	Full A	-------------------		Very steep spin
20+1		R	Flight	25W	25A	25U	Neutral	220	$1\frac{3}{4}$	
20+1		R	Normal	25W	25A	15D	Full W	216	$2\frac{1}{2}$, $2\frac{1}{4}$	
20+1		R	Normal	25W	25A	15D	Neutral	223	2	
23+20+24	10° dihedral in stabilizer (Fig. 11)	R	Normal	30W	30A	30U	Neutral	339	$\frac{3}{4}$	
23+20+24		L	Normal	30W	30A	30U	Neutral	239	$\frac{3}{4}$	
23+24		R	Normal	30W	—	30U	Neutral	375	-------------	Steep spin
23+24		L	Normal	30W	30A	30U	Neutral	239	1	

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TABLE 1 (continued)

23	L	Normal	30W	30A	30U	Full W	239	$1\frac{1}{2}$	
23	L	*Normal	30W	30A	30U	Full W	185	$4\frac{3}{4}$, $6\frac{1}{4}$, 9	
23	L	*Normal	30W	30A	30U	Neutral	185	$3\frac{3}{4}$, $3\frac{3}{4}$	
20+1+23	L	*Normal	30W	—	30U	Neutral	197	-------------	Steep spin
20+1+23	L	*Normal	25W	—	25U	Neutral	> 304	-------------	Steep spin
20+1+23	R	*Normal	25W	25A	25U	Neutral	194		
23+20+24	R	*Normal	30W	30A	30U	Neutral	188	$2\frac{1}{4}$, $2\frac{1}{2}$	
23+20+24	L	*Normal	30W	30A	30U	Neutral	185	2	
23+20+24	R	*Normal	30W	30A	30U	Neutral	188	$1\frac{3}{4}$ ----------	Nose-wheel doors in place
23	R	*Normal	30W	30A	30U	Neutral	188	$3\frac{3}{4}$, $3\frac{1}{2}$	
23+24	R	*Normal	30W	30A	30U	Neutral	182	3, $3\frac{1}{2}$	
23+20+24	R	*Normal	30W	30A	30U	Neutral	191	2	
23+20+24	R	*Normal	30W	30A	30U	Full W	185	$3\frac{1}{2}$	
23+20+24	R	*Normal	30W	30A	30U	Full W	188	3, 3 ------	Nose-wheel doors in place
23	R	Normal	30W	30A	30U	Full W	239	2	
23	L	Normal	30W	—	30U	Full W	291	------------	Steep
23	R	Normal	30W	—	30U	Neutral	339	-------------	Steep
23	L	Normal	30W	—	30U	Neutral	339	-------------	Steep
23	R	Normal	30W	—	25U	Neutral	239	-------------	Wandering
None	R	Normal	30W	30A	30U	Neutral	232		
None	R	Normal	25W	25A	25U	Neutral	176	∞	

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TABLE 1 (continued) 7

None		L	Normal	25W	—	25U	Neutral	375	------------ Very steep spin
None		R	Normal	25W	25A	25U	Rt. 3°D Lt. 3°U	176	∞
None		R	Normal	25W	25A	25U	5° A	176	∞
None		R	Normal	25W	25A	25U	Full A	176	12
None		R	Normal	25W	25A	30U	Full A	176	$6\frac{1}{2}$, 7
None		R	Normal	25W	25A	30U	Neutral	176	∞
None		R	Normal	25W	25A	35U	Neutral	182	12
None		R	Normal	30W	30A	35U	Neutral	304	$1\frac{1}{4}$, $1\frac{1}{4}$
None		R	Normal	30W	30A	30U	Neutral	176	20, 10
24	Rudder area added (Fig. 12)	R	Normal	30W	30A	30U	Neutral	176	$6\frac{1}{2}$, $6\frac{1}{4}$
24		L	Normal	30W	—	30U	Neutral	375	------------ Very steep
24		R	Normal	30W	30A	35U	Neutral	188	$3\frac{1}{4}$, $4\frac{1}{2}$
None		R	Normal	30W	30A	35U	Neutral	185	$6\frac{1}{2}$
20		R	Normal	30W	30A	35U	Neutral	239	$1\frac{1}{4}$
None		R	Normal	30W	30A	30U	Neutral	185	$4\frac{1}{2}$, 5, $5\frac{1}{2}$
None		L	Normal	30W	—	30U	Neutral	375	------------ Very steep
None		R	Normal	25W	35A	30U	Neutral	166	$7\frac{1}{4}$
None		L	Normal	35W	—	30U	Neutral	375	------------ Very steep
None		R	Normal	35W	25A	30U	Neutral	160	9
None		L	Normal	25W	—	30U	Neutral	339	------------ Very steep

TABLE 1 (continued)

24		R	Normal	30W	30A	30U	Neutral	173	$6\frac{1}{2}$, $6\frac{3}{4}$	
24		R	Normal	30W	30A	30U	Full W	166	∞	
24		R	Normal	30W	30A	30U	Full A	176	$4\frac{3}{4}$, $4\frac{1}{2}$	
24		R	Normal	30W	30A	35U	Neutral	304	1	Steep spin
24		R	Normal	30W	30A	30U	Neutral	176		
24		R	Normal	30W	30A	35U	Full W	239	$3\frac{1}{2}$	Oscillatory
24		R	Normal	30W	—	35U	Full A	>304		Very steep spin
24		R	Normal	30W	30A	0	Neutral	163	∞	
25+24	Area added below fuselage (Fig. 12)	R	Normal	30W	30A	0	Neutral	163	∞	
25+24		R	Normal	30W	30A	30U	Neutral	176	$4\frac{3}{4}$	
25+24		R	Normal	30W	30A	30U	Neutral	304	1	
25+24		R	Normal	30W	30A	30U	Full W	176	9	Two types of spin
25+24		R	Normal	30W	30A	30U	Full W	304	2	Very steep spin
25+24		R	Normal	30W	—	30U	Full A	339		Very steep spin
25+24		R	Normal	30W	—	35U	Full A	339		Very steep spin
25+24		R	Normal	30W	30A	35U	Neutral	339	1, 1	
25+24		R	Normal	30W	30A	35U	Full W	304	1, 1	Oscillatory
26+25+24		R	Normal	30W	30A	30U	Full W	176	6	Two types of spin
26+25+24		B	Normal	30W	—	30U	Full W	304		Steep, oscillatory spin
26+25+24		R	Normal	30W	30A	30U	Neutral	176	5, $4\frac{3}{4}$	

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25+24+20		R	Normal	30W	30A	30U	Neutral	325	$\frac{3}{4}$, $\frac{1}{2}$	
25+24+20		R	Normal	30W	30A	30U	Full W	234	$2\frac{3}{4}$, $2\frac{1}{2}$	
25+24+20		R	Normal	30W	—	30U	Full A	304	------------	Very steep spin
25+24+20		R	Normal	30W	30A	0	Neutral	207	$2\frac{1}{2}$, $2\frac{3}{4}$	
25+24+20		L	Normal	30W	—	0	Neutral	272	------------	Steep spin
24+20		R	Normal	30W	30A	0	Neutral	188	$3\frac{3}{4}$, 4	
24+20		R	Normal	30W	30A	30U	Neutral	201	$3\frac{1}{4}$	Two types of spin
24+20		R	Normal	30W	30A	30U	Neutral	239	$2\frac{1}{2}$	Two types of spin
24+20		R	Normal	30W	30A	30U	Full W	216	3, $3\frac{1}{4}$	Oscillatory
24+20		R	Normal	30W	—	30U	Full A	339	------------	Very steep
24+20		R	Normal	30W	30A	35U	Neutral	245	$1\frac{1}{4}$, $1\frac{1}{4}$	
27+24	Faired anti-spin fillets (Fig. 13)	R	Normal	30W	30A	30U	Neutral	252	$1\frac{1}{4}$	
27+24		L	Normal	30W	—	30U	Neutral	339	------------	Very steep spin
27+24		R	Normal	30W	30A	30U	Full W	232	3, $2\frac{1}{2}$	
27+24		R	Normal	30W	—	30U	Full A	339	------------	Very steep spin
27+24		R	Normal	30W	30A	0	Neutral	176	5, 5	
28+27+24	Area added below fuselage (Fig. 12)	R	Normal	30W	30A	0	Neutral	176	$4\frac{1}{2}$	
28+27+24		R	Normal	30W	30A	30U	Neutral	339	$\frac{3}{4}$	
28+27+24		R	Normal	30W	30A	30U	Full W	245	$2\frac{1}{4}$, $2\frac{1}{2}$	
24		R	Normal	30W	30A	30U	Full W	170	20	
24		R	Normal	30W	30A	30U	Neutral	173	9	

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TABLE 1 (CONTINUED) 10

24	R	Normal	30W	30A	0	Neutral	173	25	
24	R	*Normal	30W	30A	0	Neutral	163	∞	Nose-wheel doors in place
24	L	*Normal	30W	30A	0	Neutral	176		Nose-wheel doors in place
24	R	*Normal	30W	30A	30U	Neutral	176	10, $10\frac{1}{2}$	Nose-wheel doors in place
24	R	*Normal	30W	30A	30U	Full A	182	6, 6	Nose-wheel doors in place
24	R	*Normal	30W	30A	30U	Full W	176	$11\frac{1}{2}$, ∞	Nose-wheel doors in place, osc.
24+27	R	*Normal	30W	30A	30U	Full W	185	$4\frac{1}{2}$, $4\frac{1}{2}$	Nose-wheel doors in place
24+27	R	*Normal	30W	30A	30U	Neutral	185	$4\frac{1}{2}$, $3\frac{1}{2}$, $2\frac{1}{2}$	Nose-wheel doors in place
24+27	R	*Normal	30W	30A	30U	Full A	204	$1\frac{1}{4}$, $1\frac{3}{4}$	Nose-wheel doors in place
24+27	R	*Normal	30W	30A	0	Neutral	176	$5\frac{1}{2}$, $6\frac{1}{2}$	Nose-wheel doors in place
28+27+24	R	*Normal	30W	30A	0	Neutral	182	5, $4\frac{3}{4}$	Nose-wheel doors in place
28+27+24	R	*Normal	30W	30A	30U	Neutral	213	$1\frac{1}{4}$, $2\frac{1}{4}$, $2\frac{3}{4}$	Nose-wheel doors in place
28+27+24	R	*Normal	30W	30A	30U	Full W	194	5, 5	Nose-wheel doors in place
28+27+24	R	*Normal	30W	30A	30U	Full A	220	1	Nose-wheel doors in place
28+27+24	R	*Flight	30W	30A	30U	Full A	182	4, $3\frac{1}{2}$	Nose-wheel doors in place
28+27+24	R	*Flight	30W	30A	30U	Neutral	182	$2\frac{1}{2}$, $2\frac{1}{2}$	Nose-wheel doors in place
28+27+24	R	*Flight	30W	—	30U	Full W			Nose-wheel doors in place (Steep, osc. spin)
28+27+24	R	*Normal	30W	—	35U	Neutral			Nose-wheel doors in place (Steep spin)
28+27+24	R	Flight	30W	30A	30U	Neutral	304	$\frac{3}{4}$	
28+27+24	R	Flight	30W	—	30U	Full W	>304	-----------	Steep, oscillatory spin

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TABLE 1 (continued) //

28+27+24		R	Flight	30W	30A	30U	Full A	223	$1\frac{3}{4}$	
28+27+24		R	Normal	30W	—	30U	Rt. 20°D Lt. 20°U	>339	------------	Very steep spin
28+27+24		R	Normal	30W	—	30U	Rt. 20°U Lt. 20°D	>304	-------------	Very steep and oscillatory spin
28+27+24	Leading edge of anti-spin fillets down 5 inches full-scale	R	Normal	30W	—	30U	Neutral	>339	-------------	Very steep spin
28+27+24		R	Normal	30W	30A	0	Neutral	194	$3\frac{3}{4}$	
28+27+24		R	Normal	30W	30A	30U	Full W		$1\frac{3}{4}$	
28+27+24	Leading edge of anti-spin fillets up 5 inches full-scale	R	Normal	30W	30A	30U	Full W		2	
28+27+24		R	Normal	30W	30A	0	Neutral	176	$5\frac{1}{2}$, 5	
29+24	Tail fillets (Fig. 14)	R	Normal	30W	30A	0	Neutral	163	7, $5\frac{1}{2}$	
29+24		R	Normal	30W	30A	30U	Neutral	304	1	
24		R	Normal	30W	30A	30U	Neutral	176	$6\frac{1}{4}$	
29+24		R	Normal	30W	30A	30U	Full W	231	3	
30	Fuselage cross-section area increased near tail (Fig. 15)	R	Normal	30W	30A	30U	Full W	258	3	
30		R	Normal	30W	30A	30U	Neutral	288	1	
30		R	Normal	30W	30A	0	Neutral	163	9	
31	Tail fillets (Fig. 16)	R	Normal	30W	30A	0	Neutral	163	6	
31		R	Normal	30W	30A	30U	Full W	176	15	

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TABLE 1 (continued) 12

**24	R	Normal	30W	30A	30U	Full W	176	More than 12	
**24	R	Normal	30W	30A	30U	Neutral	182	6	
**24	L	Normal	30W	~~—~~	30U	Neutral	> 339	-----------	Very steep spin

Unless otherwise indicated, model tested in flying condition; landing condition indicated by asterisk (*)

** Elevator cutouts increased

W - With A - Against D - Down U - Up R - Right spin L - Left spin

\> 304 means in excess of airspeed shown.

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TAIL CHART 1 SPIN CHARACTERISTICS RIGHT ERECT SPINS

MODEL XP-39E EFFECT OF MODIFICATION LOADING NORMAL COCKPIT CLOSED LANDING GEAR RETRACTED FLAP SETTING NEUTRAL

RECOVERY BY RAPID RUDDER REVERSAL (RUDDER WITH THE SPIN PRIOR TO RECOVERY ATTEMPT)

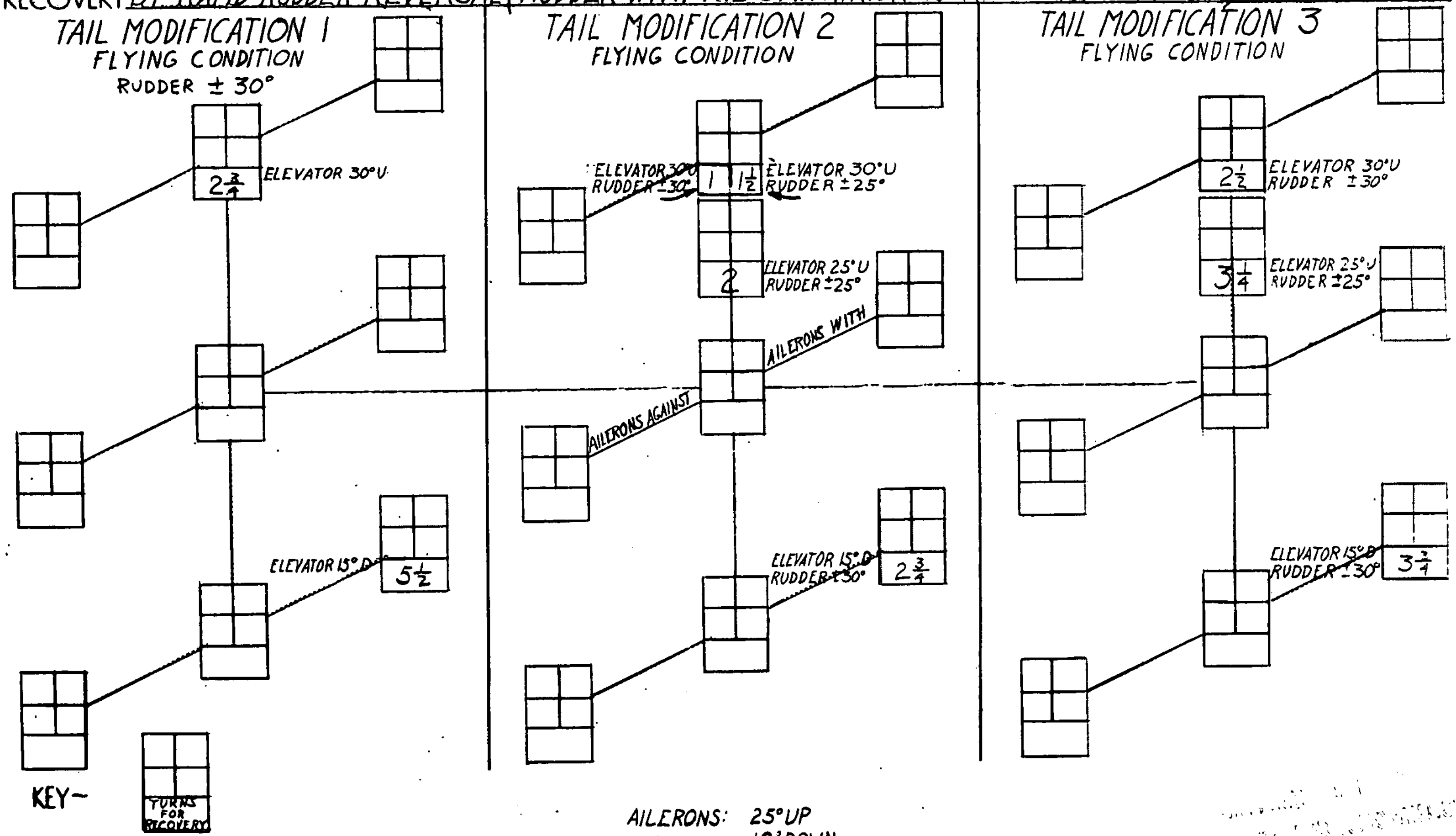
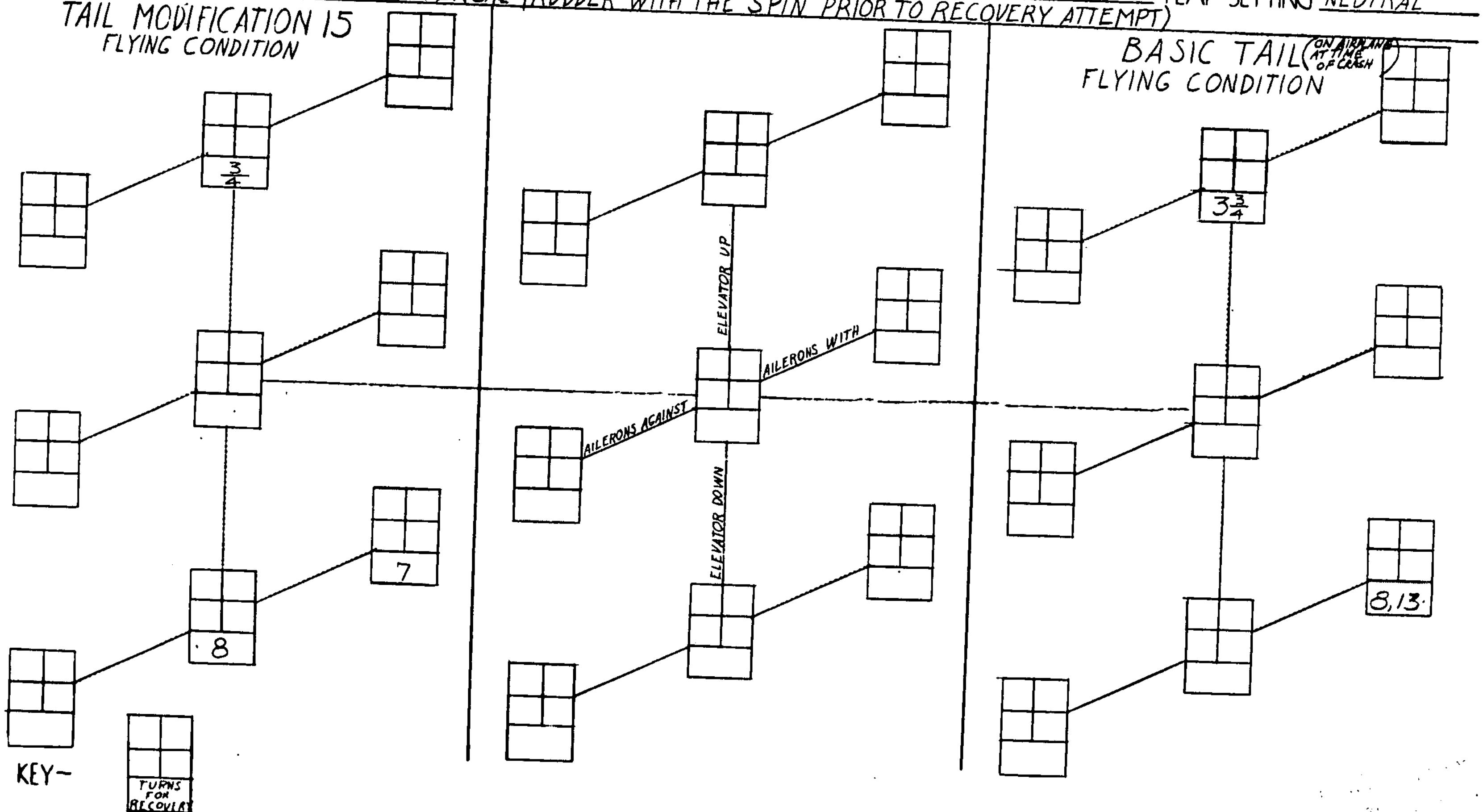


CHART 2

MODEL XP-39E EFFECT OF TAIL MODIFICATION LOADING NORMAL SPIN CHARACTERISTICS RIGHT ERECT SPINS
RECOVERY BY RAPID RUDDER REVERSAL (RUDDER WITH THE SPIN PRIOR TO RECOVERY ATTEMPT) COCKPIT CLOSED LANDING GEAR RETRACTED FLAP SETTING NEUTRAL



RUDDER ±25°
AILERONS 25° UP
10° DOWN
ELEVATOR-UP SETTING 25°
-DOWN SETTING 15°

CHART 5 SPIN CHARACTERISTICS RIGHT ERECT SPINS

MODEL XP-39E EFFECT OF CONTROLS LOADING NORMAL COCKPIT CLOSED LANDING GEAR AS INDICATED FLAP SETTING AS INDICATED

RECOVERY BY RAPID RUDDER REVERSAL (RUDDER WITH THE SPIN PRIOR TO RECOVERY ATTEMPT)

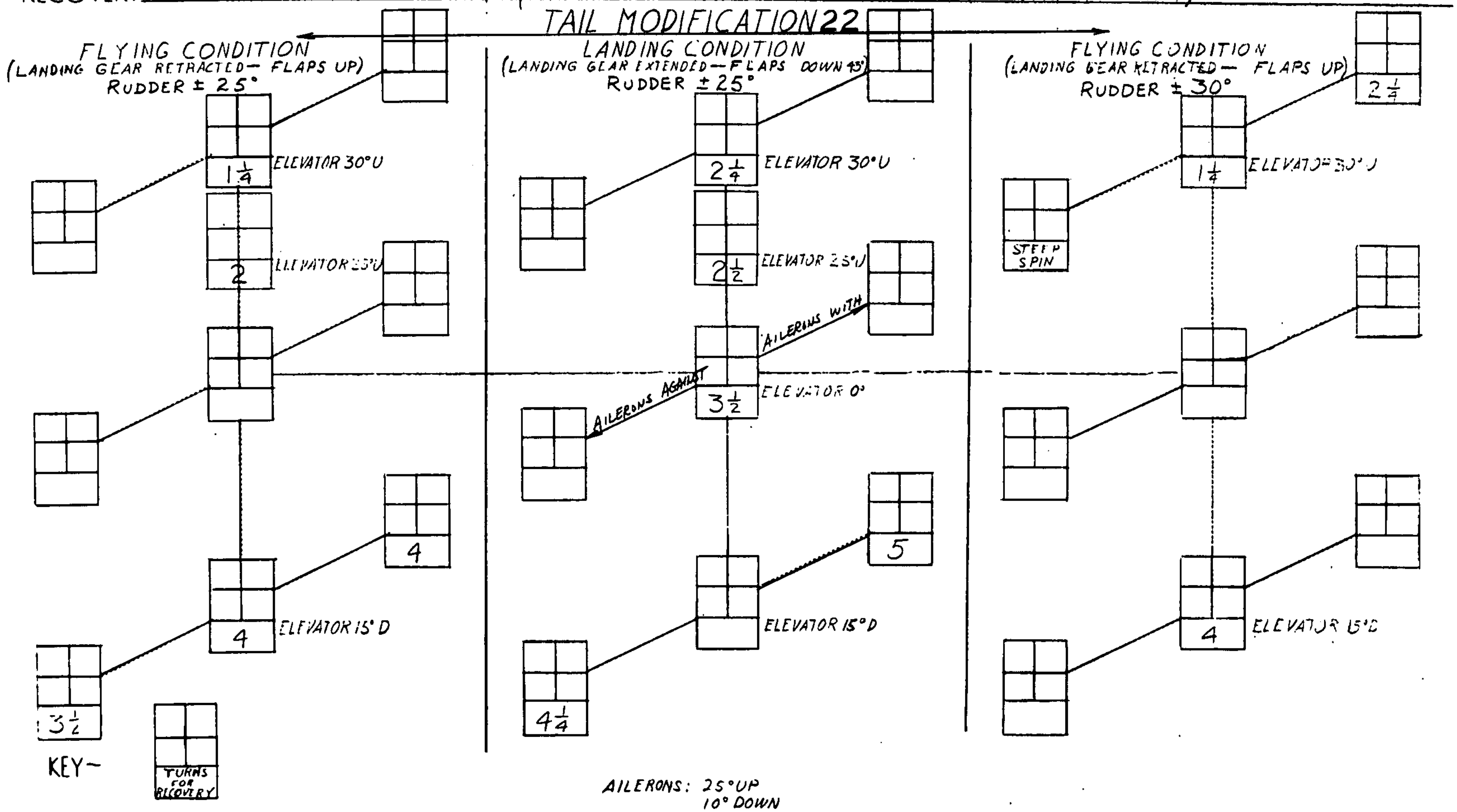


CHART 4 SPIN CHARACTERISTICS RIGHT ERECT SPINS

MODEL XP-39E EFFECT OF CONTROLS LOADING NORMAL COCKPIT CLOSED LANDING GEAR AS INDICATED FLAP SETTING AS INDICATED

RECOVERY BY RAPID RUDDER REVERSAL (RUDDER WITH THE SPIN PRIOR TO RECOVERY ATTEMPT)

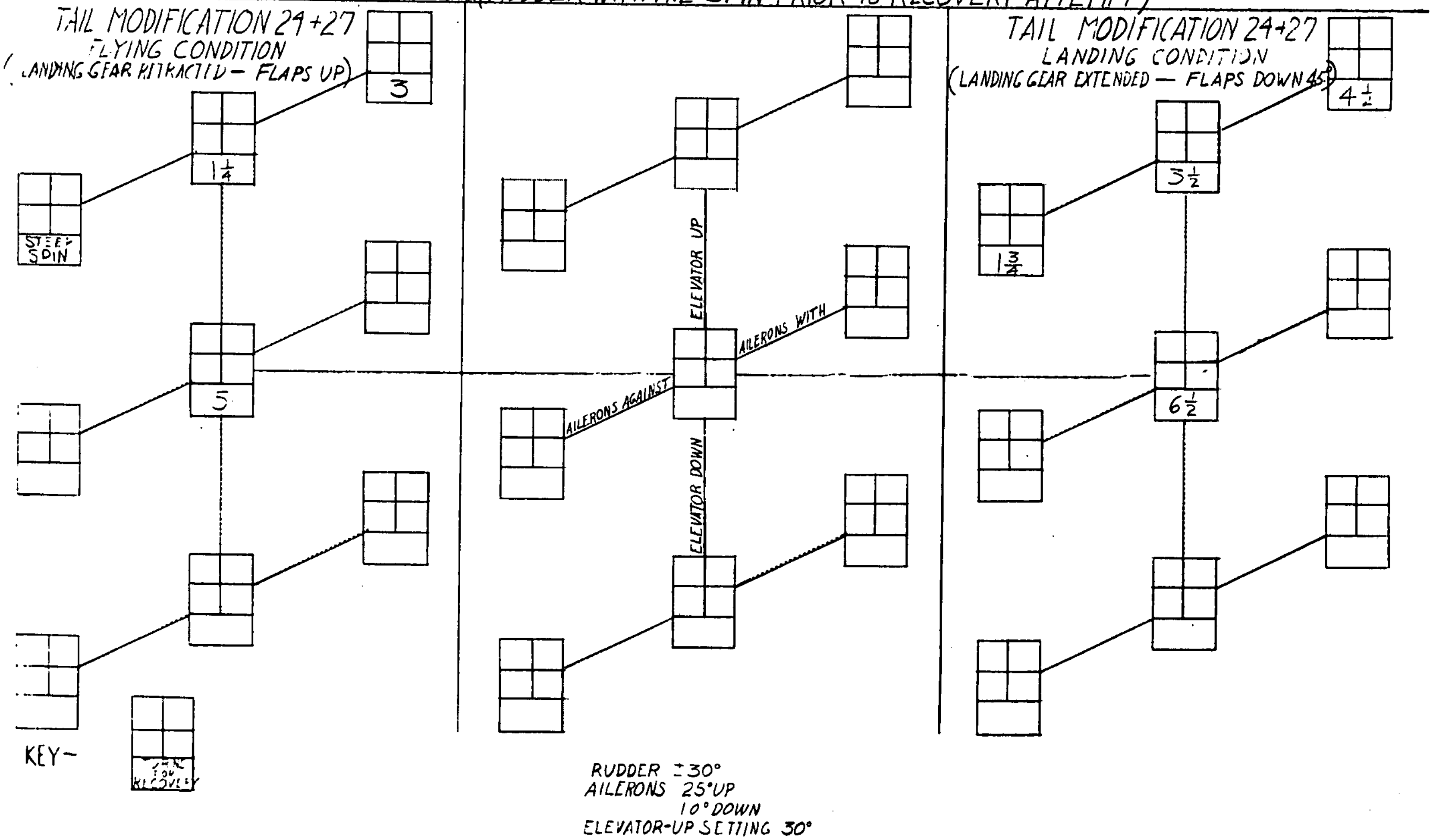
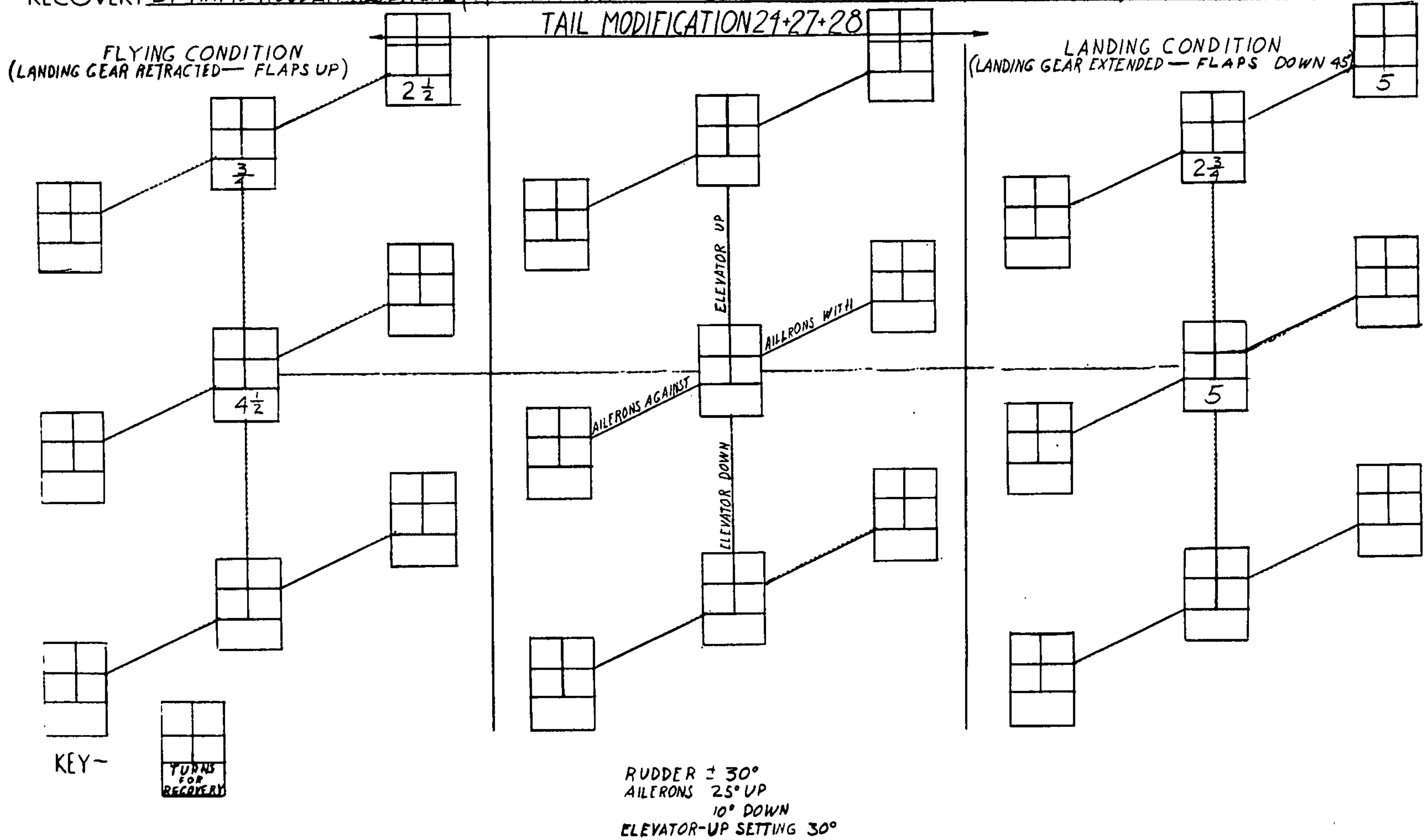
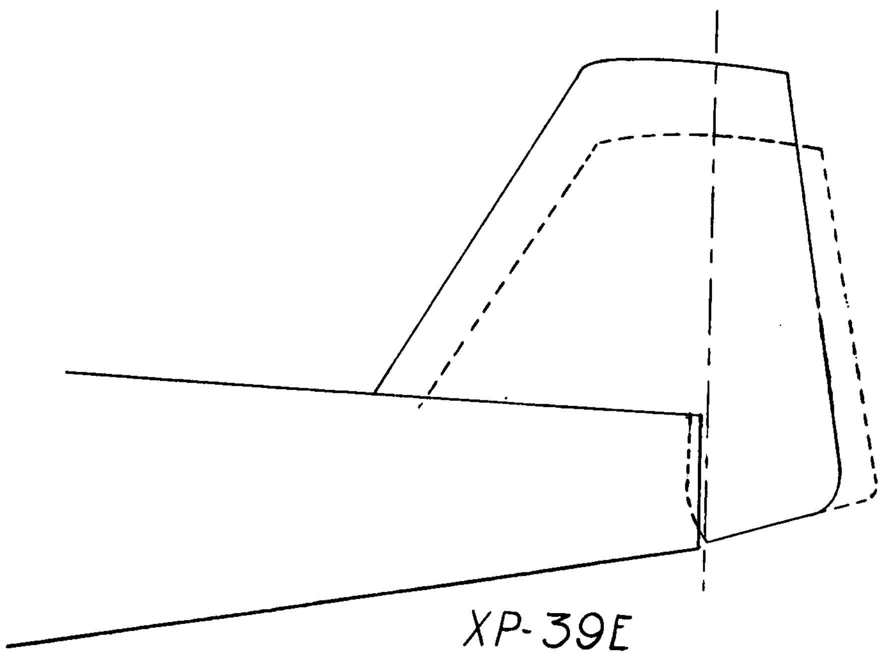


CHART 5 SPIN CHARACTERISTICS RIGHT ERECT SPINS

MODEL XP-39E EFFECT OF CONTROLS LOADING NORMAL COCKPIT CLOSED LANDING GEAR AS INDICATED FLAP SETTING AS INDICATED

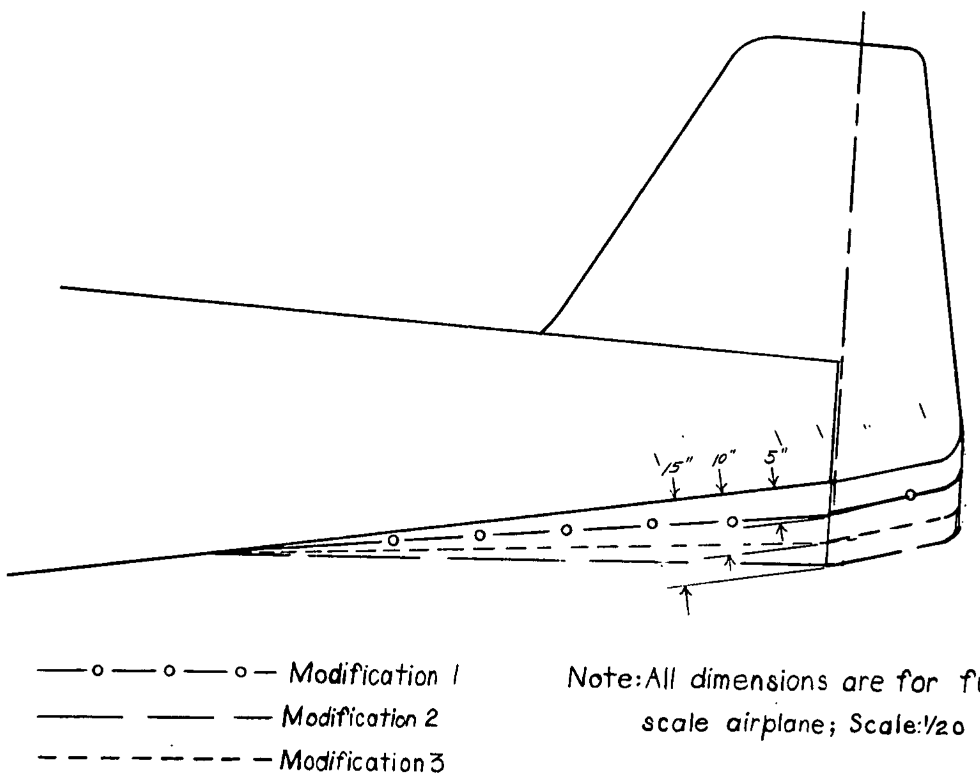
RECOVERY BY RAPID RUDDER REVERSAL (RUDDER WITH THE SPIN PRIOR TO RECOVERY ATTEMPT)





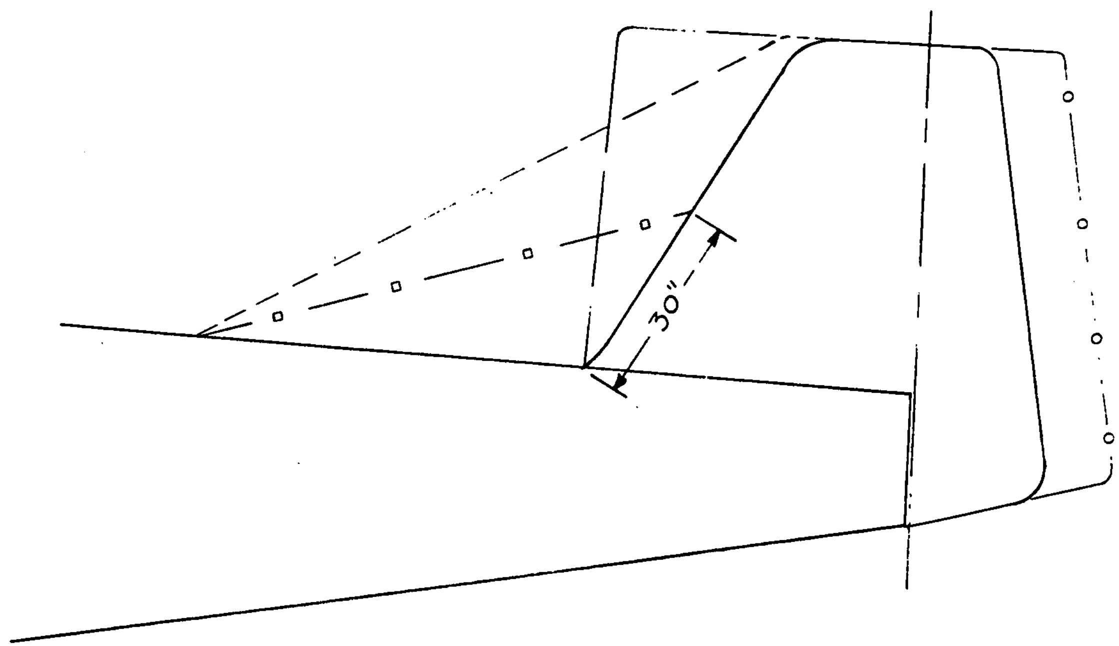
XP-39E

Figure 1- Comparison between vertical tail surface on airplane at time of crash(solid line) and the original (dashed line)



Note: All dimensions are for full-scale airplane; Scale: 1/20

Figure 2 - XP-39E TAIL MODIFICATIONS



Modification 4
Modification 5
Modification 6
Modification 7

Note: All dimensions are for full scale airplane; Scale: 1/20

Figure 3- XP-39E TAIL MODIFICATIONS

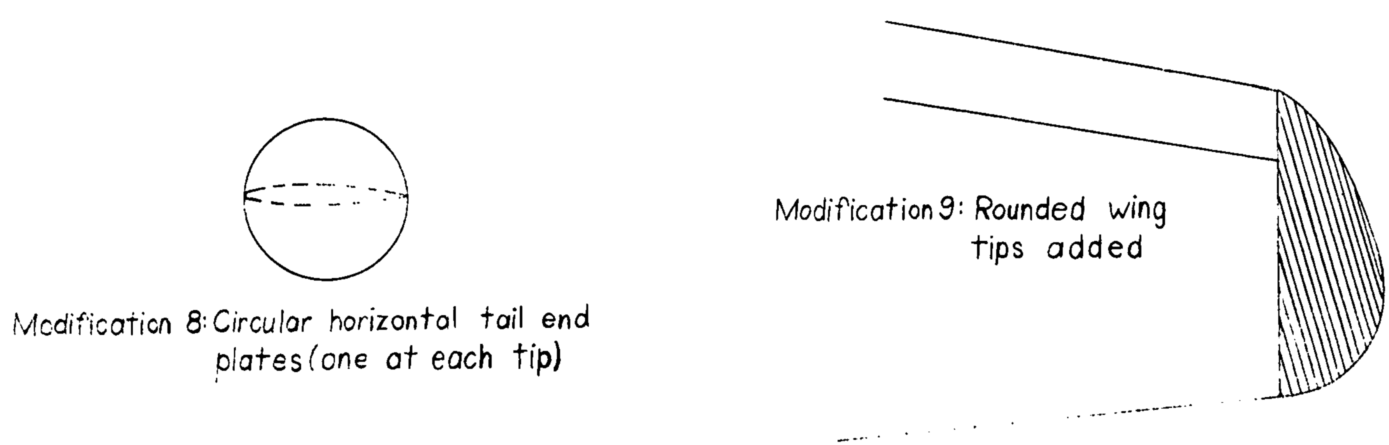


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Figure 4 - XP-39E TAIL MODIFICATIONS

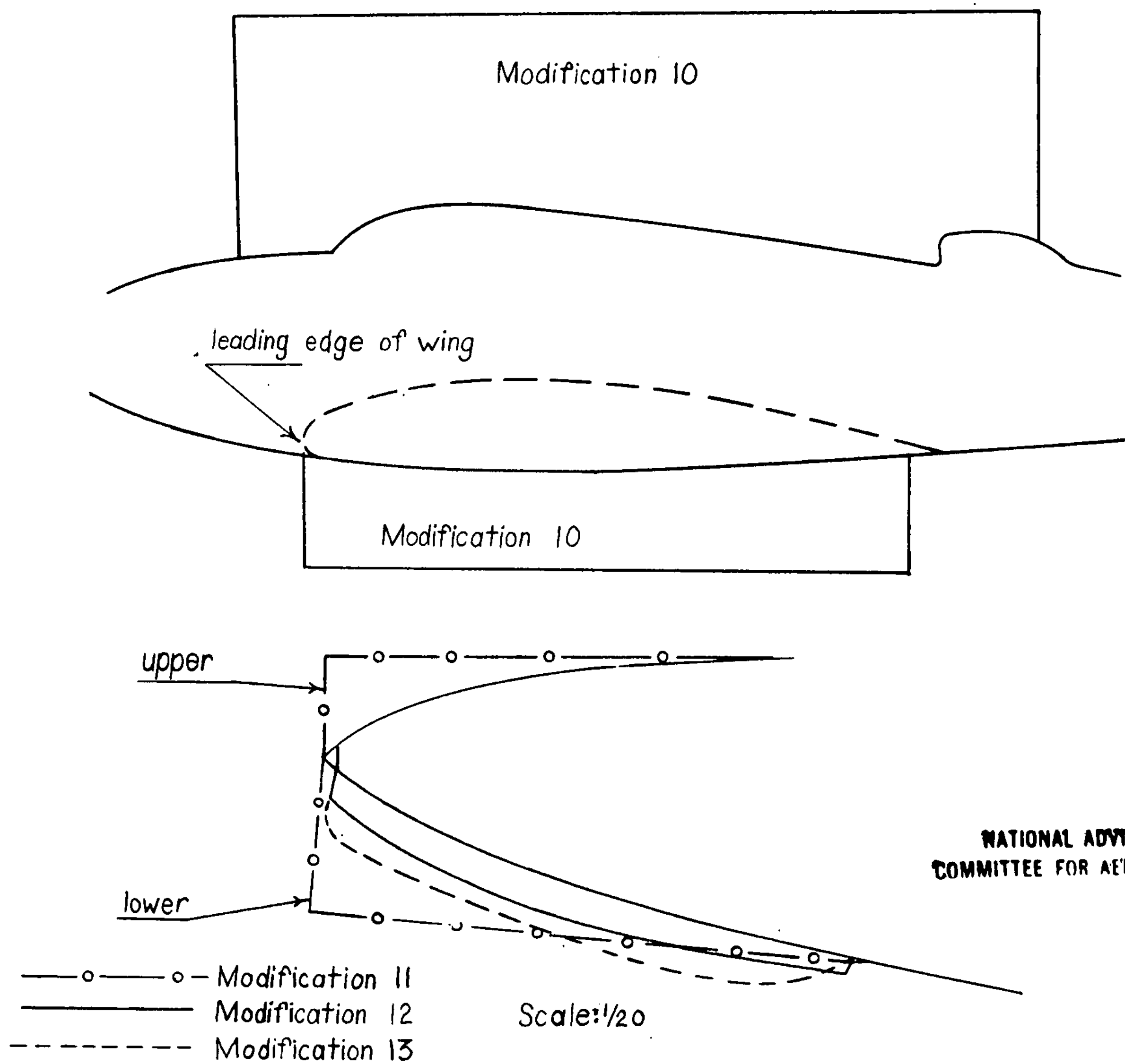
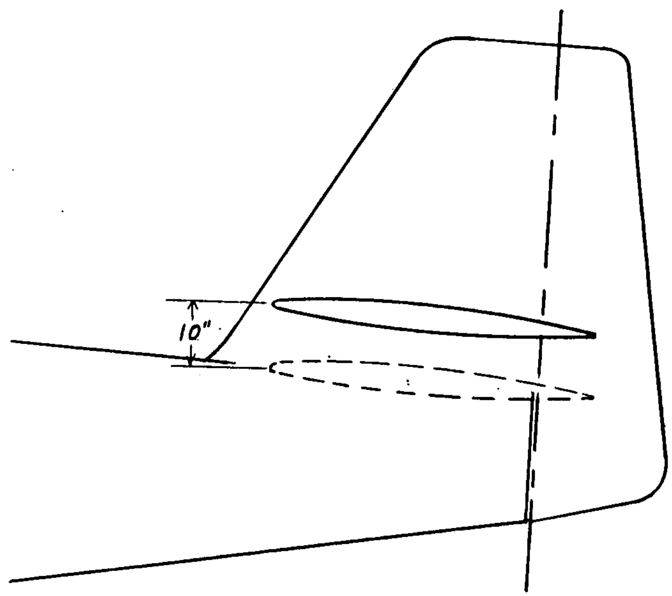
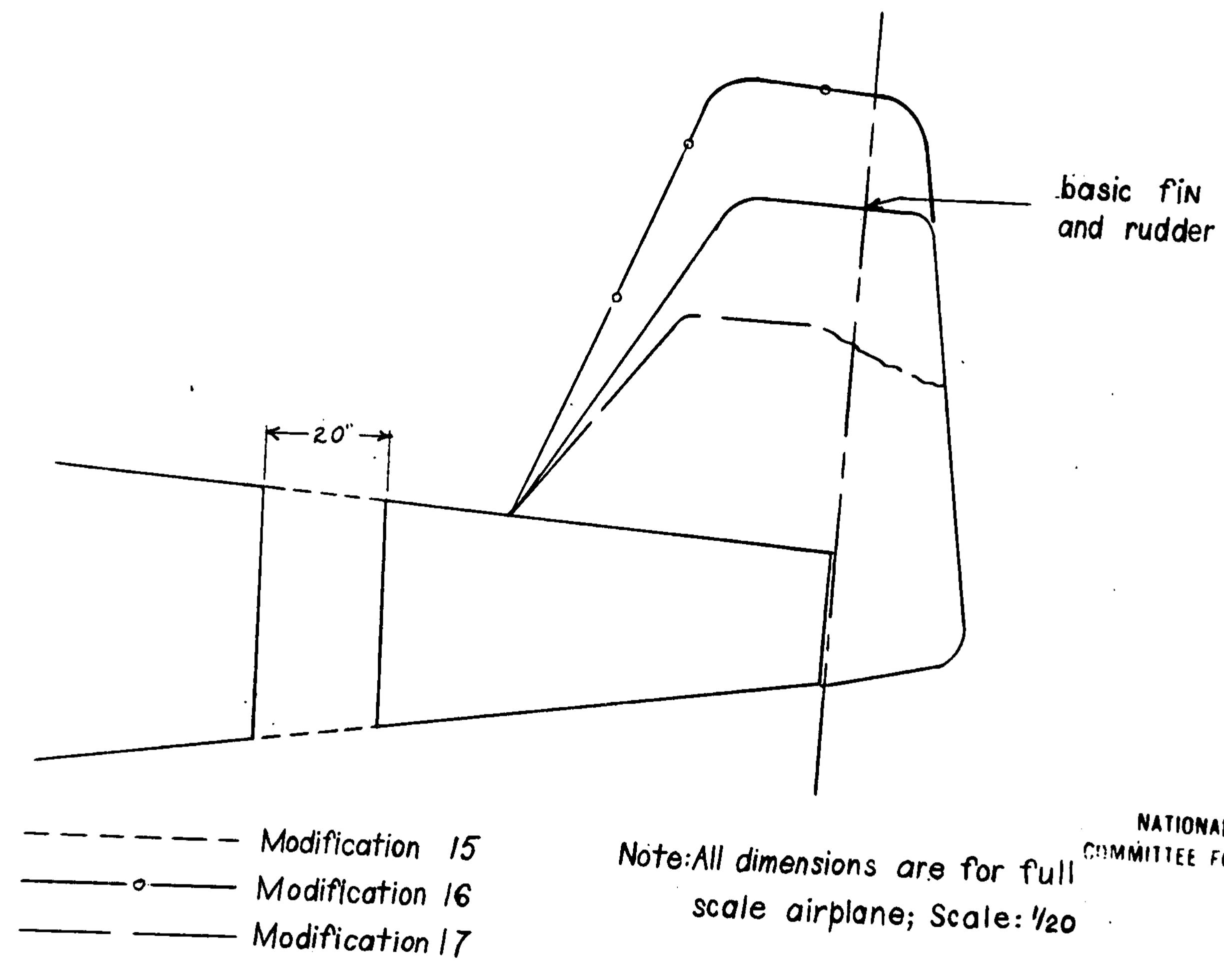


Figure 5- XP-39E INCREASED LATERAL AREA



Modification 14 (raised stabilizer)
Note: All dimensions are for full scale airplane; Scale: 1/20

Figure 6-XP-39E TAIL MODIFICATIONS



Note: All dimensions are for full scale airplane; Scale: 1/20

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Figure 7- XP-39E TAIL MODIFICATIONS

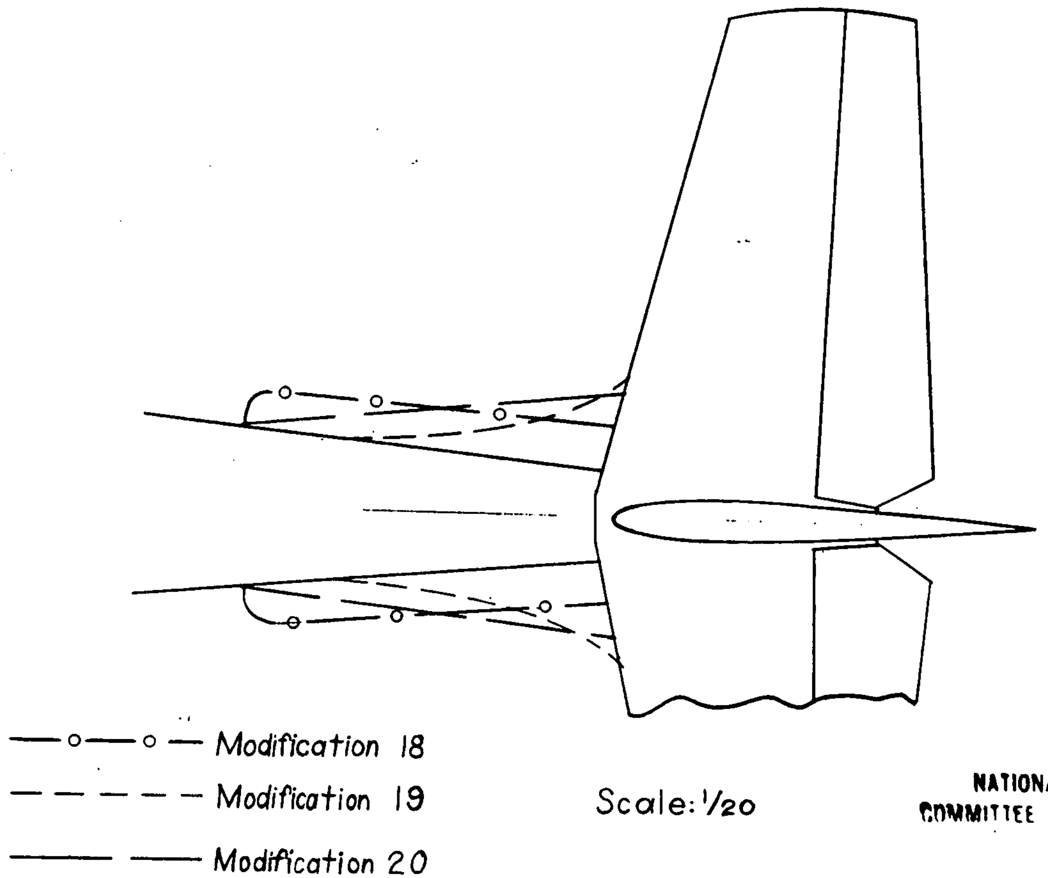
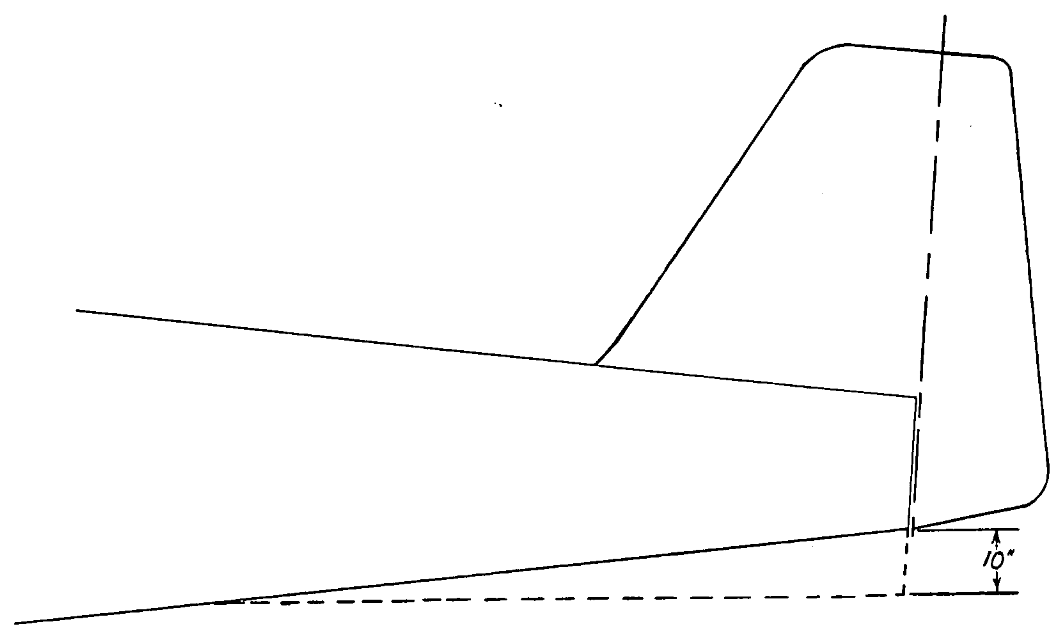


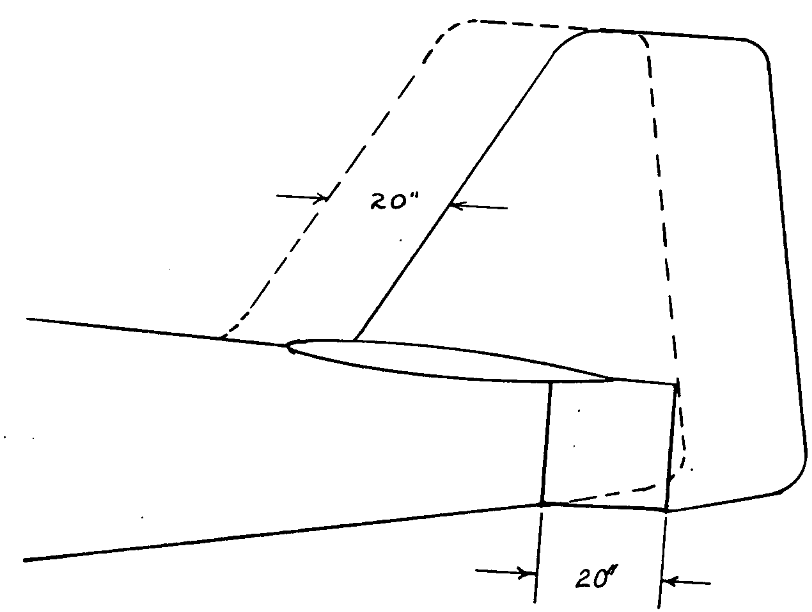
Figure 8- XP-39E TAIL MODIFICATIONS



------------ Modification 21

Note: All dimensions are for full scale airplane; Scale: 1/20

Figure 9- XP-39E TAIL MODIFICATIONS



- - - - - Original tail position

——— Modification 22 (new tail position)

Note: All dimensions are for full scale airplane; Scale: 1/20

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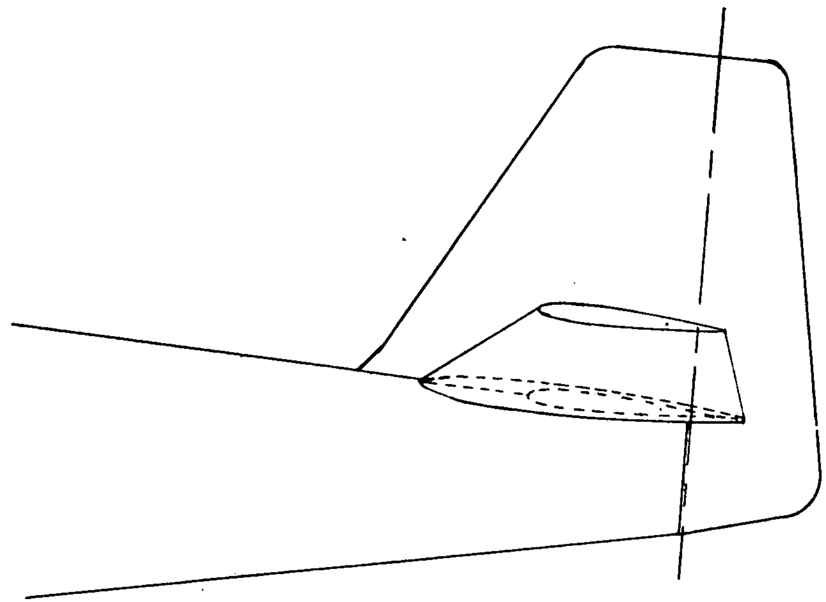
Figure 10-XP-39E TAIL MODIFICATIONS



Modification 23 New horizontal tail, dihedral 10°

Original tail, dihedral 0°

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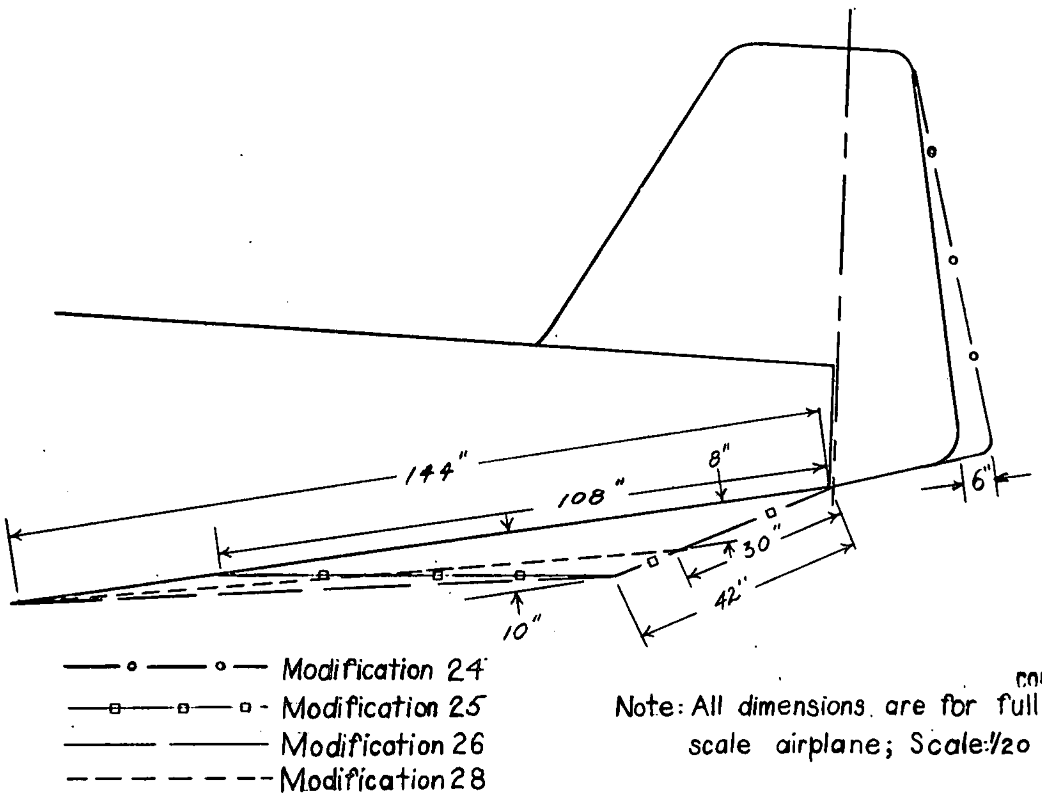
Scale: 1/20

Figure 11 - XP-39E TAIL MODIFICATIONS



Note: All dimensions are for full scale airplane; Scale: 1/20

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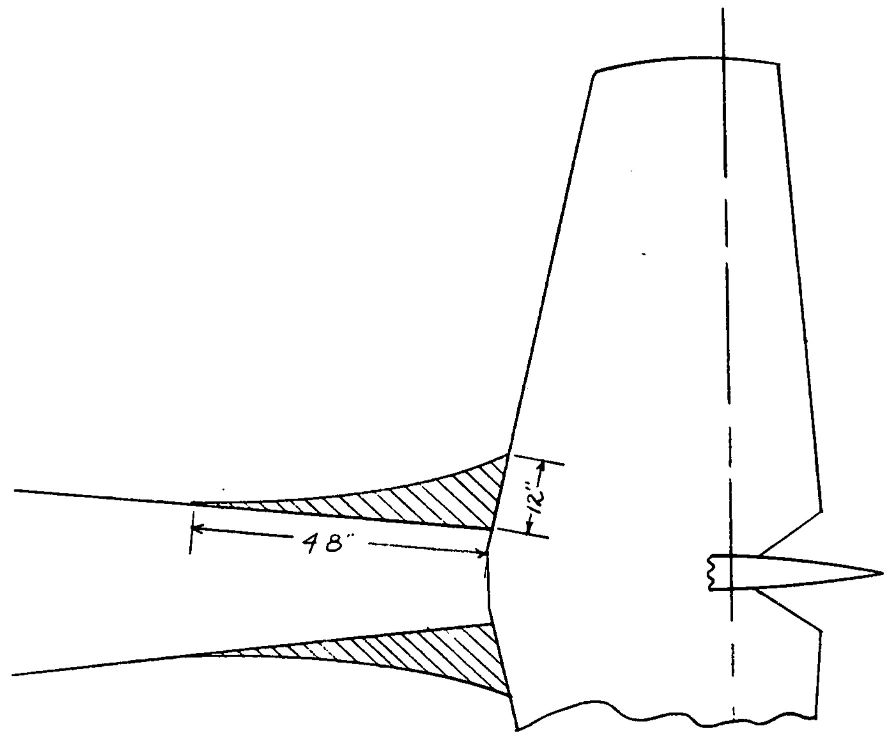
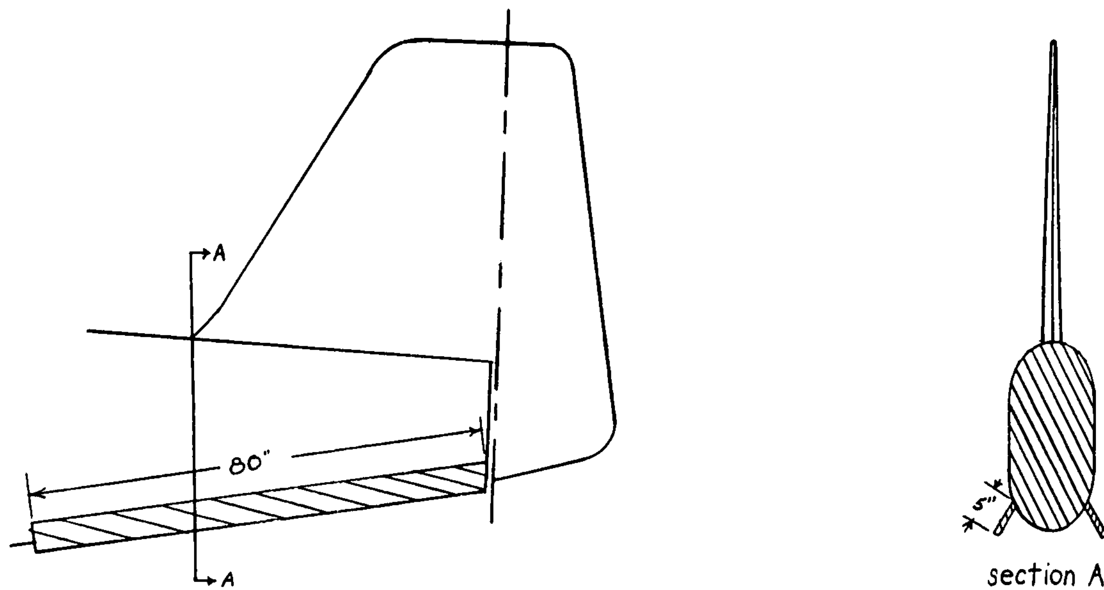
Figure 12-XP-39E TAIL MODIFICATIONS

By W.S.
J.H.S.



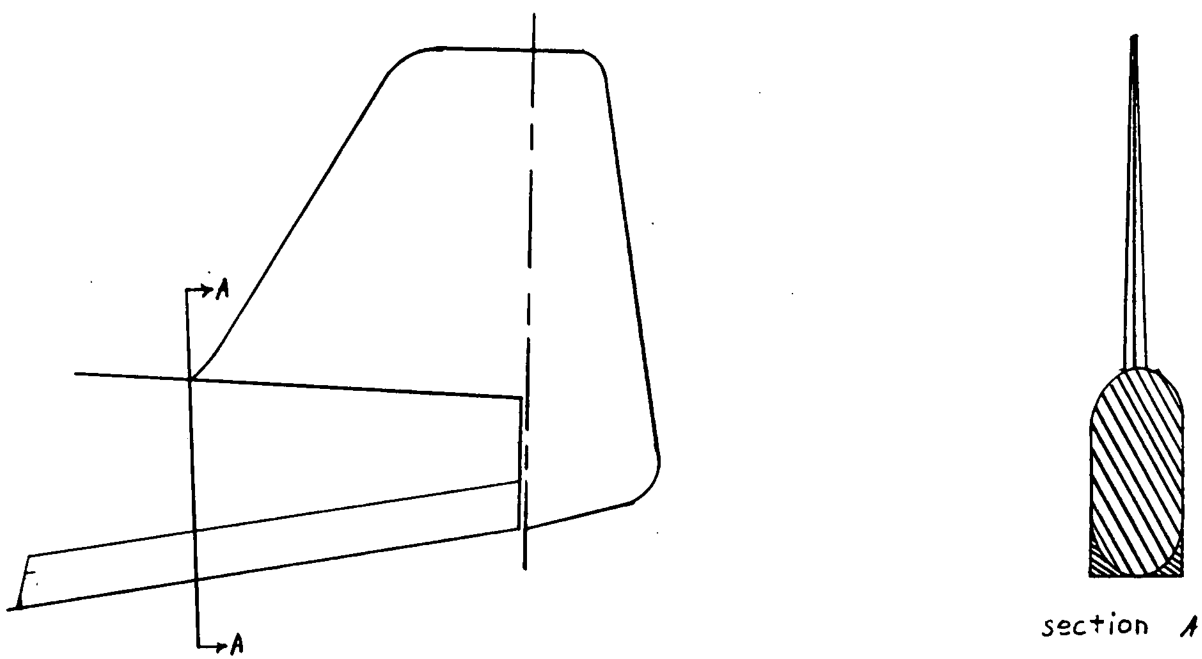
Modification 27 (anti-spin fillets)
Note: All dimensions are for full scale airplane; Scale: 1/20

Figure 13 - XP-39E TAIL MODIFICATIONS



Modification 29 (tall fillets)
Note: All dimensions are for full scale airplane; Scale: 1/20

Figure 14-XP-39E TAIL MODIFICATIONS



Modification 30 (fuselage cross sectional area increased)
Note: All dimensions are for full scale airplane; Scale: 1/20

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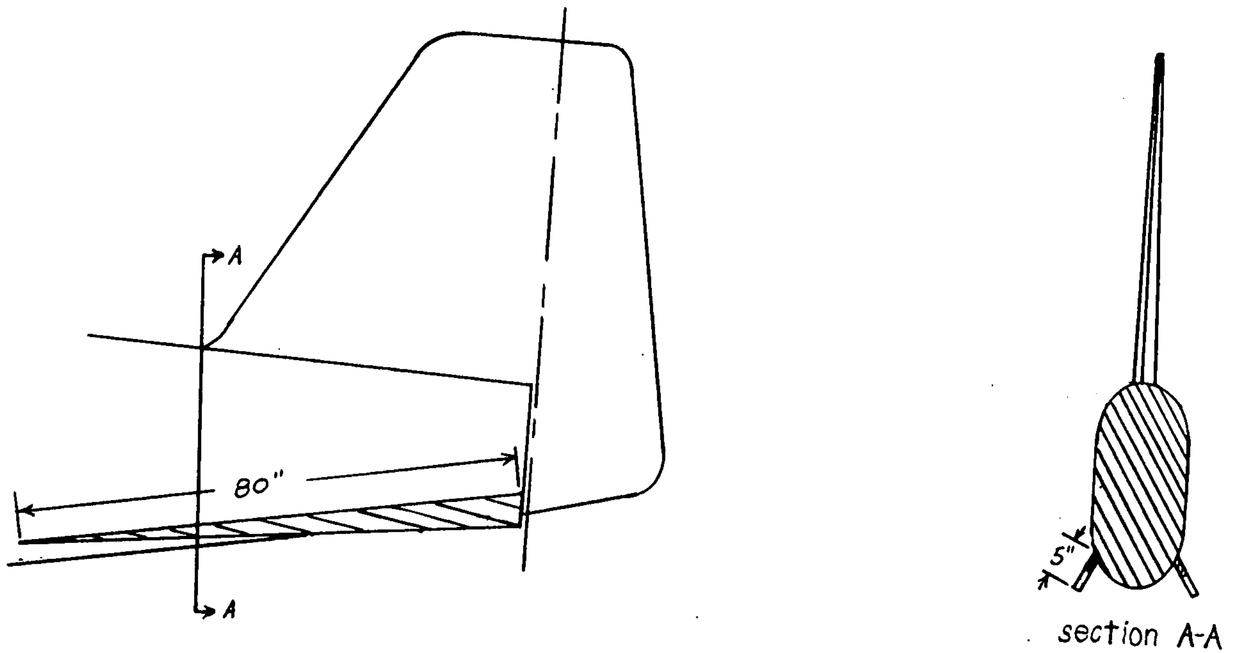
Figure 15 — XP-39E TAIL MODIFICATIONS



Modification 31 (tail fillets)
Note: All dimensions are for full scale airplane; Scale: 1/20

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Figure 16 - XP-39E TAIL MODIFICATIONS